Restoration of Stamp Marks and Development of an Etching Paste

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In the Round - A Day Aimed at Firearms Experts, 8 June 2010, The Royal Armouries, Leeds

Introduction

Stamped identification marks may be erased or defaced by the criminal but the process of stamping deforms the underlying metal structure and this can sometimes be recovered by etching. The use of a liquid etchant is, however, not very convenient in the field or when dealing with surfaces that are not flat. An investigation was therefore carried out to see whether a suitable etching paste could be made.

The study also examined the conditions necessary to completely remove the underlying changes to the crystal structure and a tentative model is proposed to explain how deep the underlying damage is. This may help assessing the potential success of recovering marks.

Method

To understand the factors affecting recovery, a series of steel discs or bars were prepared by impressing a single letter using a die and a hydraulic press. The specimen was carefully filed to just obliterate the letter and the disc thickness was measured. A pre-determined additional layer of material was removed (0.5-2.0 mm) and Fry's reagent was applied. Periodically this was removed, the specimen observed, and etching was continued if recovery was not achieved. If no recovery was achieved after 9 hours the test was terminated. Over-stamped samples were treated in a similar manner with 1 mm removed below the original imprint.

In order to make a paste Fry's reagent was mixed with alumina powder in the ratio 3.5 ml to 4 g to give a suitable consistency. It was intended to try other reagents, but this combination proved very successful and often etched better than the liquid reagent.

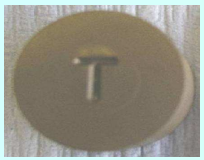

Fig 1. Original mark

Fig 2. Defaced mark

Fig 3.Recovered mark

Depth of Impression.

The depth of impression was recorded by measuring how much material had to be removed to obliterate the mark. It was, however, noticed under the optical microscope that burrs of metal from filing tended to infill the groove and weld together (figure 4). This appeared to be more of a problem with imprints made with low applied force, possibly because the metal burrs stay attached to the metal surface and a shallower depression is easier to in-fill. A consequence from a forensic point of view is the criminal is likely to believe the mark is obliterated, but during the etching stage liquid can penetrate and remove this infill and produce a sharper mark.

Fig 4. Infilling

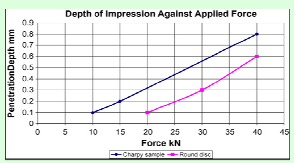

Fig 5. Depth of impression

Fig 6. Recovery

Figure 6 shows the appearance of the letter V with etching of the strained area visible, but a much clearer mark where the in-filled impression was.

Figure 5 shows the measured depth of metal that needed to be removed in order to obliterate the imprint and corresponds with the imprint depth. From the graph it can be seen that there is a difference between the two series, probably due to the different yield strengths of the two materials.

Recovery.

The results of the etching tests show that the greater the applied force the deeper the impression. Below 20 kN little impression was made and above 40 kN the main body of the die started to make an impression. Up to 1 mm below the original imprint the impression could be recovered. Beyond this recovery was less likely.

During the filing burrs are forced into the depression of the stamp mark and some adhere to the base metal and weld together to fill the void. Consequently the imprint is obliterated more easily than expected. In this case the imprint reappears more easily than expected as this extraneous material is leached away. This imprint has a much clearer edge than etching of the re-orientated grain structure, as seen in Figure 6

Over-stamping with a cold chisel appears to make the imprinted letter unreadable, but the chisel damage is much more localised and a letter may still be recovered. This is due to the localised deformation caused by the chisel in comparison with the die.

Grinding on a grinding wheel may be easier for a criminal than filing, and in this study it removed the lettering easily but it caused limited underlying damage and recovery was relatively easy. In fact, no further polishing of the sample was required when grinding was used.

Filing was most effective at obliteration and required more sample preparation for recovery. However, it requires the manual removal of at least 2 mm of metal below the imprint to be effective.

A Model of Underlying Damage

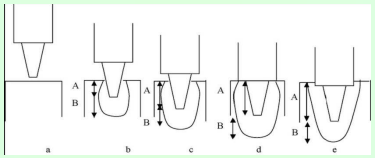

Fig 7. Diagram of Limit of Plastic Deformation

It is suggested that recovery can be achieved where plastic deformation of the metal has occurred, and this will depend on the force applied and the yield stress of the metal. The model is discussed further in reference 1.

Development of the Paste

A paste could be easier to apply in field applications, and in order to produce a paste a range of options were considered. Mixing Fry's reagent with alumina was tried initially, and was surprisingly successful. Consequently work focussed on this paste rather than examining alternative systems.

It was observed that the paste produced a chromatographic effect and this affects the concentration of different ions present in contact with the metal.

Fig 8. Ion separation in paste

Fig 9 Paste during etching

It was also noted that the paste etched in a different way, giving a broader pattern that was more easily visible to the naked eye (figure 9). The paste also avoided copper deposition on removal and the formation of a black oxide layer that reduces contrast. The mechanism is discussed in reference 2.

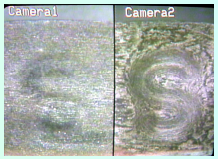

Fig 9. Identical Samples Etched with Liquid (left) and Paste (right)

Merits of the Paste

The ratio of liquid and solid can be adjusted to produce a reagent that will stay in place and not flow. After etching the paste can be wiped off (subject to suitable safety precautions) and a clean metal surface is obtained. Often the paste will etch better than liquid, but as with any new or modified technique, toolmark examiners need to gain experience in order to make a judgement of when to use it.

Conclusion

Further understanding has been gained of when erased marks may be recovered, and a paste has been developed that may be useful in recovering erased stamp marks.

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1. Restoration of stamp marks on steel components. Forensic Science International, Volume 180, Issue 1, Pages 32 – 36, G. Wightman, J. Matthew.

2. Development of an etching paste. Forensic Science International, Volume 180, Issue 1, Pages 54 – 57, G. Wightman , J. Matthew